

C E M E N T AND CEMENT MANUFACTURE

PUBLISHED 20TH OF EACH MONTH.

PRICE 1/- A COPY.

ANNUAL SUBSCRIPTION 12s. POST FREE.

PUBLISHED BY CONCRETE PUBLICATIONS LTD.,
20, DARTMOUTH STREET, LONDON, S.W.1.

TELEPHONE: VICTORIA 4551.

TELEGRAPHIC ADDRESS:

CONCRETUS, PARL, LONDON.

PUBLISHERS OF

"CONCRETE & CONSTRUCTIONAL ENGINEERING"

"CONCRETE BUILDING & CONCRETE PRODUCTS"

"CEMENT & CEMENT MANUFACTURE"

"THE CONCRETE YEAR BOOK"

"CONCRETE SERIES" BOOKS, ETC.

VOLUME 5. NUMBER 3

MARCH 1932

The Hardening of Portland Cement.

By J. E. LOVENTHAL,

CHIEF ENGINEER, STATE TESTING LABORATORY, COPENHAGEN.

IN CEMENT AND CEMENT MANUFACTURE, 1931, page 1115, and 1932, page 19, the question of the hardening of Portland cement has been discussed by Mr. F. F. Tippmann and Professor Kühl.

Without entering into a complete discussion on the subject, I may perhaps point out that the results of some experiments carried out in the Danish State Testing Laboratory in Copenhagen in another connection seem to prove that Mr. Tippmann's opinion that the hydrolysis of the calcium silicates of clinker in the presence of water is complete so that the final products are silica gel and calcium hydroxide cannot possibly hold true.

The experiments in our laboratory were made with the so-called *Mo-ler*, i.e., a Danish eocene diatomaceous sea-water deposit, rich in silica, which is used as a pozzolana in connection with Portland cement; but the experiments can be checked in any chemical laboratory with other pozzolanas, such as trass, kieselguhr, or the like.

In Experiment No. 1 a sample of *Mo-ler* was ground to a residue of 4 per cent. on a sieve with 5,000 meshes per square centimetre, and the amount of silica soluble in hydrochloric acid was determined in this sample by treating a certain quantity of it with 3 per cent. hydrochloric acid. The amount was 2 per cent. SiO_2 .

In each of a series of bottles was placed 1.5 gram pure quicklime, which was heated with 25 c.c. distilled water so that the lime was thoroughly slaked. After cooling, 2 grams of the *Mo-ler* sample and 175 c.c. of distilled water were added to each bottle, and the bottles were carefully corked and occasionally shaken.

At intervals of 33 and 74 days later the amount of silica soluble in 3 per cent. hydrochloric acid in the bottles was determined. The amount of soluble silica of the *Mo-ler* was 14 per cent. after 33 days' storage and 24.4 per cent. after 74 days' storage, the results being in all cases calculated on the *Mo-ler* substance in an ignited state.

In Experiment No. 2, 20 parts of the sample of *Mo-ler* were mixed with 80 parts of ordinary Portland cement. The amount of soluble silica in the

mixture was determined (by treating with 3 per cent. hydrochloric acid) as 16.4 per cent. The mixed cement was then gauged with water, and small test-pieces were moulded and stored in distilled water for periods of 28 days, 3 months, and 12 months.

The amount of soluble silica was then determined, and was found to be 19.6, 22.3, and 23.6 per cent. respectively after 28 days, 3 months, and 12 months. A calculation shows that the amount of soluble silica of the Mo-ler has thus increased from 2 per cent. to 18.1, 33.5, and 40.8 per cent. respectively. The results were calculated on the Mo-ler substance in an ignited state.

This considerable increase of the amount of soluble silica in the Mo-ler can hardly be explained by a mere physical action (absorption, capillarity, or surface force) of the slaked lime or the cement-lime on the finely divided particles of silica of the Mo-ler, but is probably due to the formation of some hydrosilicate of lime, which is soluble in diluted hydrochloric acid.

In this case, however, it cannot possibly be assumed that the hydrolysis of the calcium silicates of cement with water should go on to the ultimate products (silica gel and calcium hydroxide), when at the same time a calcium silicate is formed by the action of free lime on free silica or hydrated silica.

Notes from Abroad.

Belgian Cement Output.

The output of cement in Belgium for the month of December, 1931, was 140,000 tons, or 42 per cent. of total capacity. This compares with 176,000 tons in December, 1930, or 53 per cent. of capacity. The deliveries in December, 1931, were 110,000 tons, compared with 130,000 tons in December, 1930. These figures represent percentages of capacity of 33 and 39 respectively.

French Cement Company Reports.

We understand that Etablissements Poliet et Chausson propose to pay a dividend of 80 francs (16 per cent.) for 1931, which compares with 120 francs (24 per cent.) paid in 1930.

The trading reports of the Société des Ciments Français for 1931 are satisfactory. Sales amounted to 688,513 tons, compared with 662,477 tons in the previous year. The dividends on "capital" and "jouissance" shares are maintained at 250 francs (40s. 3d.) and 225 francs (36s. 3d.) respectively.

Belgian Cement Company Report.

S.A. des Ciments Portland Belges d'Harmignies has declared a dividend of 35.10 francs net (4s.) for the year 1931, with a net profit of 2,773,635 francs (£15,849). This compares with a dividend of 42.90 francs net (4s. 11d.) in 1930 and a net profit of 3,554,299 francs (£20,310) in 1930.

Cement Sales in Germany.

It is stated that the sales of the Deutscher Zement Bund for the year 1931 amounted to 3,718,000 tons, compared with 5,512,000 tons in 1930 and 7,040,000 tons in 1929.

Green Island Cement Works, Hong Kong.

By HENRY POOLEY, Jun., B.Sc., A.M.Inst.C.E., A.M.I.Mech.E.

In April, 1931, an article appeared in this journal on the new wet-process Portland cement works then being installed by the Green Island Cement Company in Hong Kong, describing some details of the plant. On September 1, 1931, the first machinery was started on a production basis. On September 28 the first kiln was lighted, and on October 14 the first cement was packed and despatched from the works. Since that date the works has been in full operation, and it is now possible to publish summaries of some of the results of tests carried out on the various sections of the plant. The particulars which follow are of interest in this connection.

Raw Mills.

The dimensions of the raw mills are 40 ft. by 6 ft. 6 in. diameter, and they are direct coupled through reduction gearing to 475 h.p. synchronous motors. During the test the loading of the mill was 6 tons 16 cwts. of 5-in. and 4-in. balls in the primary compartment, 7 tons 18 cwts. of 3-in. and 2-in. balls in the second compartment, and 17 tons of 1-in. and $\frac{3}{4}$ -in. balls in the final chamber. The mill speed was 25 r.p.m.

The limestone fed to the mill was crushed to 1-in. size and under, while the fineness of the clay slurry was 11 per cent. on the 180-mesh sieve. Slurry from the mill was pumped into one of the reinforced concrete slurry tanks, inside which was a ladder with rungs spaced 1 ft. apart, which served as a scale for the measurement of the slurry. The mill was tested for a period of 8.4 hours, and the amount of slurry manufactured during this time corresponded to 11 ft. in the tank. The average fineness during the period of the test was 7.7 per cent. residue on the 180-mesh sieve, while the water content amounted to 35.5 per cent. The calcium carbonate content was 77.5 per cent., and the density of the slurry 1.688. The corresponding quantity of dry raw material per foot run of the slurry tank amounted to 10.978 tons, and therefore the total quantity of dry raw material ground during the test was 120.75 tons. As the test lasted for 8.4 hours this corresponds to an output of 14.37 tons per hour. The ammeter reading throughout was constant at 105 amps. As 100 amps. in this particular case is equivalent to 475 b.h.p., the power being supplied to the mill was 500 b.h.p. This represents a power consumption used by the mill of 26.1 kw. hours per ton. The actual units used by the motor were 3,403, which represents a consumption of 28.2 kw. hours per ton, which includes all electrical losses.

Cement Mills.

The cement mills are 36 ft. long by 6 ft. 6 in. diameter, and during the test they were loaded with 6.5 tons of 5-in. and 4-in. balls in the primary compartment, 8 tons of 3-in. and 2-in. balls in the second compartment, and 15 tons of 1-in. and $\frac{3}{4}$ -in. balls in the final chamber. The mill speed was 25 r.p.m., and, as before, was driven by a 475 h.p. synchronous motor through reduction gearing.

The clinker used for the test was taken after lying in the clinker store only a few hours, and in many cases it was still hot. The method of measuring the clinker was to weigh 80 tons into the cement mill bunker. The test was run until the bunker was emptied. Gypsum was added in the proportions mentioned later. In this case the duration of the test was 8.67 hours. The average fineness of the cement obtained during the test was 4.67 per cent. on the 180-mesh sieve. Gypsum was ascertained by a chemical analysis at 3.39 per cent., and therefore the quantity of gypsum ground during the same period was 2.8 tons. This makes a total quantity of cement produced 82.8 tons, or 9.45 tons per hour. The

ammeter reading throughout the test was 84, and the power absorbed by the mill was 30 kw. hours per ton. Including electrical losses the power absorbed was 32.5 kw. hours per ton.

Kilns and Coal Mills.

The kilns are of the Reflex type, with the cooler in prolongation of the kiln and with cooling cylinders spaced around the periphery of the cooler. These are furnished with chains in the upper end extending a distance of about 70 ft. The kiln length is 240 ft. and the diameter is 7 ft. 9 in. by 11 ft. by 9 ft. The overall length, including the cooler, is 254 ft. The two kilns installed were tested over a period of one week and operated throughout in conjunction with an air-swept coal plant and Lodge-Cottrell dust precipitation plant.

The air-swept coal plant comprises two 2-compartment mills, each 7 ft. 3 in. in diameter by 7 ft. 10 in. long, direct coupled through gearing to motors. The ball charges in the primary chamber amount to 2 tons 14 cwts. of 3-in. and 2-in. steel balls, and in the second chamber 6 tons of 1-in. and $\frac{3}{4}$ -in. cast-iron balls. Hot air is drawn from the coolers through the mill, and grinding and drying take place in the one unit. The coal is separated by a cyclone and stored in a separate hopper for blowing into the kiln.

The quantity of slurry used was measured in the manner described in connection with the raw mill, and an allowance was made of 0.5 per cent. of coal for every per cent. of water in the slurry above 36 per cent., upon which figure the guaranteed output and coal consumption of the kiln were based. The quantity of clinker was calculated from the quantity of dry raw material contained in the slurry delivered to the kilns. It was also checked by means of a weigher delivering clinker to the store.

All the coal bins were filled to capacity, carefully trimmed at the beginning of the test, and returned to the same condition at the conclusion. The weight of coal was ascertained by an automatic weighing machine, which was carefully calibrated once a day during the test. The proportion of mixed coal used was 1.86 parts of Hongay coal (anthracitic) to one part of Miki coal (high volatile). The coal consumption was corrected for water in the slurry in excess of 36 per cent. for moisture in the coal and for the calorific value of the coal.

The following is a summary of the results obtained:—

(a) RAW MATERIAL: Total used	3,050.30 tons
(b) COAL: Total Hongay (anthracitic) used	308.7 "
" Miki (high volatile)	165.7 "
Total mixed coal	474.4 "
Proportion of Hongay to Miki	1.86 : 1.0
Average volatile matter	21.07 per cent.
" B.T.U.s per lb.	13,300
" Moisture	8.6 per cent.
" Ash	10.86 "
" Fixed carbon	68.49 "
Coal mill, hours run	141
Coal mill, tons ground per hour	3.36
Coal mill, power per ton	25.6 kW. hours.
(c) KILN DATA: No. 1 Kiln average back end temperature	536.5 deg. F.
" " average clinker temperature	211.5 deg. F.
No. 2 " average back end temperature	554.0 deg. F.
" " average clinker temperature	220.0 deg. F.
Total output	1,993 tons
Running hours	305
Tons per hour	6.53 (each)
Coal consumption (uncorrected)	23.80
" Standard " coal consumption (corrected)	22.11
Power per ton of clinker including firing fan, exhaust fan and kiln motors	13.28 kW. hours

Preliminary Tests for Cement of the New German Standard Specification.

BY G. HAEGERMANN.

THE recent German specification for Portland cement (CEMENT AND CEMENT MANUFACTURE, December, 1930) includes preliminary tests for setting time and soundness (viz., the finger-nail test and the boiling test respectively) for use on the building site. The finger-nail test determines the time which elapses after mixing until light pressure with the nail no longer makes an impression in a cement pat; this must be at least three hours. The test is really a determination of final setting time, from which it is assumed that initial set will not take place before the lapse of one hour. The following analysis shows, however, that the finger-nail test will be in error in $1\frac{1}{4}$ per cent. of the cases in which it is used. More than 10,000 tests with the Vicat needle were compared. In forty-eight cases the final setting time was more than three hours, although

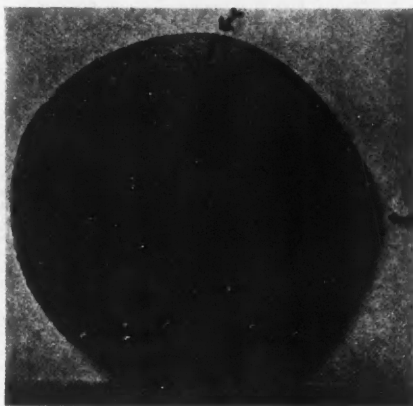


Fig. 1.

initial set was less than one hour, i.e., the cements were not normal setting. In eighty-four cases final set occurred in less than three hours, while the initial setting time was more than one hour, i.e., the cements were normal setting. The finger-nail test would thus give 132 errors in 10,500 cases, or $1\frac{1}{4}$ per cent. It is therefore recommended that the Vicat needle should be used on the site wherever possible.

In view of the desirability of having a reliable yet simple test for the direct determination of initial set for use on the site, the following was developed and is recommended: A cement pat of normal dimensions and an iron rod with a rounded end 4 mm. in diameter are required. In place of the latter a conical metal cap, such as is used to protect the point of a lead pencil, may be used, the diameter of the conical end being 3 to 4 mm. This is pressed into the pat $1\frac{1}{2}$ cm. from the edge, perpendicularly to the glass plate. Initial set has occurred when a crack is formed connecting the hole made by the rod with the edge of the pat.

In the case of a slow-setting cement, (I) the pat was still pasty one hour after mixing, so that no crack was formed; (II) after two hours the rod was again applied and a few hair cracks radiated from the hole formed; (III) repetition of the test three hours after mixing (one-quarter hour before initial set) gave well-defined cracks which no longer closed up, but no crack reached the edge of the pat; (IV) $3\frac{1}{4}$ hours after mixing, in addition to several radiating cracks, the characteristic crack from the hole to the edge of the pat was formed. This corresponded to the initial set as given by the Vicat needle. The Roman numerals correspond to those on Fig. 1.

The determination of final set is much less important, and the finger-nail test suffices. It can also be determined by cutting 2-mm. thick slices from the edge of the pat with a knife. Final set has occurred when the mass crumbles and the slice comes away in scales. The most certain criterion is the occurrence of fine cracks running to the glass plate at an angle of 45 deg.

The accelerated boiling test for soundness may definitely exclude cements that are perfectly sound. In 1891 the Association of German Portland Cement Manufacturers arranged for the Government Testing Station (Materialprüfungsamt) to test ten cements which did not withstand the boiling test, but which were satisfactory in practice. Test-pieces of various shapes made from these cements, including ornamental medallions containing much detailed design, were exposed in the open for 35 years without deterioration. The cements also satisfactorily withstood the usual tests, including the cold water soundness test.

The fact that the finger-nail and boiling tests are not beyond reproach is recognised in the requirement of the standard specification, that cements giving unfavourable or doubtful results in these tests must be submitted to the "authoritative" tests.

[These notes are abstracted from a recent article by Dr. Haegermann in *Zement*.]

The German Cement Industry in 1931.

The production of Portland cement, iron Portland cement, and blast furnace cement in Germany decreased from 7,000,000 tons in 1921 to 5,500,000 tons in 1930, and to 3,700,000 tons in 1931. The deliveries in December, 1931, amounted to 109,000 tons, which represents half the deliveries in December, 1930. The export trade has also decreased. During the period January to November, 1931, including deliveries for reparation purposes, 546,000 tons were exported, while 904,000 tons were exported during the same period in 1930. It is anticipated that the Dutch cement market may be lost in the present year as a result of competition from other countries. The annual production of cement in Germany during the years 1928-1931, in metric tons, has been as follows: 1928, 7,640,000; 1929, 7,105,000; 1930, 5,510,000; and 1931, 3,689,000.

Cement Companies' Dividends.

The following profits and dividends have been declared for the year 1930-1931 (the figures in brackets are those for the previous year): Queensland Lime and Cement Co., Ltd., £18,842, 6% plus 2% bonus (£30,064, 6% plus 2% bonus); Kandos Cement Co., Ltd. (associated with Australian Cement, Ltd., as Australian Portland Cement Pty.), £43,762, 5% (£118,340, 10%); Standard Portland Cement Co., Ltd., Australia, £39,451, 5½% (£47,872, 8%); S. A. John Cockerill, Seraing, Belgium, 15,302,305 fr. (?) (71,319,622 fr., 78 fr.); Milburn Lime and Cement Co., Ltd., New Zealand, £23,131, 10% (£21,154, 10%).

The Estimation of Free Lime in Cement.

By DR. G. A. ASHKENASI,

CHIEF CHEMIST, THE PORTLAND CEMENT CO., "NESHER," LTD. (PALESTINE).

In the article by the writer published in the February number of this journal the method used in our laboratory of estimating the quantity of free lime in Portland cement was described. By examination of different cements it was observed that the proportion of free lime detected in well-sintered clinkers ground without gypsum was the same, independently of whether the cement was, before being titrated, dried at 120 deg. C. or ignited at 1,000 deg. C. until constancy of weight was obtained. Cements which contained gypsum, when ignited until constancy of weight, showed a considerable increase in the proportion of free lime in comparison with the same cement dried at only 120 deg. C. Further, it was observed that the amount of free lime rose with the duration of ignition and with the quantity of gypsum added. But generally, after eight hours of heating at 1,000 deg. C., and with the content of 4 to 5 per cent. of gypsum in cement, a maximum was attained.

In order to investigate these phenomena it was decided to continue the examinations, and the further results are described in the following. The tests were partly executed by my assistant, Mr. L. Klavansky. The first tests had been carried out with cements obtained by grinding clinker with gypsum bihydrate. Now gypsum bihydrate has been substituted by anhydrite.

Two samples of cement were prepared by grinding clinker, which had been stored for a considerable time, with 3 per cent. of gypsum bihydrate and 3 per cent. of anhydrite respectively. The titration of these two samples by the glycerol tartaric acid method gave the following results :

	Per cent. of CaO detected in samples.	
	Dried at 120 deg. C.	Ignited at 1,000 deg. C. during 18 hours.
Cement with 3 per cent. of $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$..	0.35	(1) 10.58 (2) 10.21
Cement with 3 per cent. of CaSO_4	0.40	(1) 10.11 (2) 10.33

The results showed that the substitution of gypsum bihydrate by anhydrite did not effect any change in the amount of CaO detected. These tests were repeated many times with different cements with variable proportions of gypsum bihydrate and anhydrite, and in all cases no difference in the action of these two kinds of gypsum was noticed.

In the older cement literature it was stated that Portland cement heated for a long time at a high temperature lost part of its qualities as a hydraulic hardening material, while it was also assumed that the heating of Portland cement caused decomposition of the ferro-calcium compounds.*

Before arriving at a conclusion on the influence of gypsum on the decomposition of cement by heating, it was decided to examine more closely the behaviour of cement without gypsum subjected to continuous ignition. Three kinds of Portland cement clinker were used.

* F. Wecke, *Handbuch d. Zementliteratur*, 1927, p. 510.

(a) *Clinker D*.—A sharp-sintered clinker taken directly from the discharging lock of a rotary-grate shaft kiln.

(b) *Clinker E*.—A well-sintered clinker, but of a more porous structure, also taken from the discharging lock.

(c) *Clinker F*.—An average product taken from the clinker store after four weeks' storage.

These three clinkers were ground without gypsum to such a fineness that no residue remained on a sieve with 10,000 meshes per square centimetre (about 250×250 per square inch).

The chemical composition of these cements was as follows:

	D	E	F
	Per cent.	Per cent.	Per cent.
Loss on ignition :	0.1	1.02	1.50
SiO ₂	21.15	21.10	20.77
Al ₂ O ₃	6.65	6.11	6.04
Fe ₂ O ₃	3.75	3.36	3.30
CaO	67.02	66.45	65.86
MgO	0.98	1.00	1.72
SO ₃	trace	0.60	0.34
Alkalies and loss	0.35	0.34	0.43

The cement obtained was heated for several days at about 1,000 deg. C. in an electrical muffle furnace. From time to time samples of 1 gr. were taken and titrated for estimation of CaO. The results of these tests were as follows:

Time of ignition.	Percentage of CaO detected in cement.		
	D	E	F
2 hours	(1) 0.45	1.83	6.84
	(2) 0.45	2.11	6.70
8 hours	(1) 2.01	3.54	6.84
	(2) 2.35	3.34	6.70
24 hours	(1) 5.20	4.78	7.60
	(2) 4.60	4.98	7.20
48 hours	(1) 6.42	5.89	10.92
	(2) 6.22	5.73	10.82
70 hours	(1) 8.30	8.98	12.01
	(2) 8.00	8.58	12.11
110 hours	(1) 9.57	—	12.31
	(2) 9.69	—	12.01

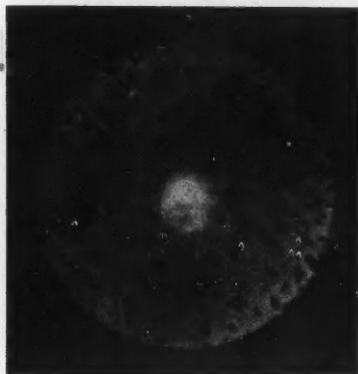
The results obtained show that Portland cement without gypsum, when heated, evolves CaO, the amount of which increases with the duration of heating.

When Clinker D was ground with 5 per cent. of gypsum bihydrate and heated under the same conditions, and then examined for presence of CaO, 9.41 per cent. of CaO was found to be contained in a sample which had been ignited during eight hours only. It is evident that the heating of cement causes decomposition, and it is to be assumed that the presence of gypsum accelerates

the process of this decomposition. The accelerating effect of gypsum in respect of the amount of CaO evolved in cement by heating to a high temperature is represented in the following table. These tests were carried out on Cement E:

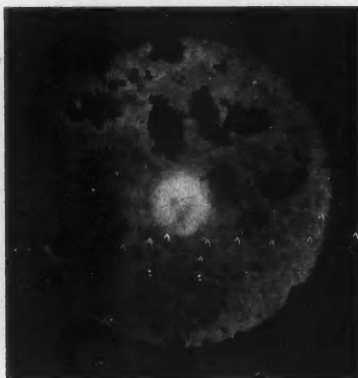
Time of heating.	Percentage of CaO detected in		Loss percentage on ignition.	
	a	b	a	b
	Cement without gypsum. (Average of two tests).	Cement with 4 per cent. gypsum.		
4 hours	2.18	4.47	1.02	1.26
8	3.44	8.69	1.025	1.26
24	4.88	9.17	1.025	1.26
48	5.81	—	—	—
70	8.78	9.25	—	—

It was necessary to heat Cement E without gypsum during seventy hours to 1,000 deg. C. in order to obtain nearly the same amount of CaO which had already been obtained after eight hours' heating of the same cement with 4 per cent. of gypsum. The constancy of weight was obtained by both cements



Photograph of Cement D without Gypsum before being ignited.

Magnified 200 times.



Photograph of Cement D without Gypsum after 110 hours' ignition.

Magnified 200 times.

after about two hours' heating. Loss on ignition was 1.02 to 1.26 per cent. respectively. The analysis for SO_3 in the cement with gypsum which had been heated for twenty-four hours gave 1.948 per cent. of SO_3 . The theoretical amount of SO_3 for the 4 per cent. of gypsum bihydrate in this cement is equal to 1.86 per cent., a proof that gypsum was not decomposed during this heating.

It was further found that different cements behaved differently in respect of the accelerating effect of gypsum on their decomposition by heating. Thus, in Cement D, which contained 5 per cent. gypsum, after ignition for eight hours, 9.41 per cent. CaO was detected, which amount was found in the

same cement free of gypsum only after it had been heated at the same temperature for 110 hours.

For the Cement E the corresponding period was seventy hours.

Cement F without gypsum heated to 1,000 deg. C. showed, after forty-eight hours of ignition, 10.87 per cent. CaO; after seventy hours, 12.06 per cent. CaO; whilst the same cement with 5 per cent. gypsum showed after eight hours' heating 11.58 per cent. CaO. In general it was observed that the cements less sharply sintered, or underburnt, required a shorter period of ignition, and the difference of the time of heating between a cement without gypsum and the same cement with gypsum becomes smaller. As we had examined well-burnt cements, which showed after a short ignition without gypsum a comparatively insignificant proportion of free lime, our first thought was to directly relate the decomposition of cement with the presence of CaSO_4 . A closer examination showed that this decomposition also takes place in pure cement after a long period of heating. The presence of gypsum only accelerates this process.

When barium sulphate was substituted for gypsum the accelerating effect was not obtained.

Three samples of Cement D were ignited during twenty hours at 1,000 deg. C. and then titrated for determination of CaO. The results were as follows:

	Percentage of CaO (average of two tests).
Cement D free of gypsum	4.24
Cement D with 5 per cent. BaSO_4 ..	3.89
Cement D with 5 per cent. CaSO_4 ..	9.25

The microscopical examination carried out on the preparations of cement free of gypsum before and after ignition showed a distinct alteration in the crystalline form. The well-known sharp crystals of cement appeared partly corroded after ignition.

Unfortunately, as a very simple photomicrographic camera was used no very sharp photographs were obtained, but even the two here reproduced show the deformations on the periphery of the crystals of cement which were ignited.

Further investigations are being undertaken.

New Ruston-Bucyrus Excavator.—Ruston-Bucyrus, Ltd., announce an addition to their standard Diesel-driven excavators. This machine (the "52-B") can be equipped for use as dragline, shovel, grabbing crane or crane. It is the largest "straight-Diesel" convertible excavator the firm has produced, and is fitted with a six-cylinder "Ruston" Diesel engine of 160 B.H.P., specially built for excavator duty. As a shovel, the machine is fitted with a bucket of $2\frac{1}{2}$ cub. yd. level capacity with a boom 31 ft. long, or alternatively with a bucket of 2 or $1\frac{1}{2}$ cub. yd. capacity with correspondingly greater boom length. As a dragline or grabbing crane the booms vary in length from 50 to 75 ft. in ratio to the bucket capacity, which varies from $2\frac{1}{2}$ to $1\frac{1}{2}$ cub. yd. The standard width of the caterpillar tracks is 36 in.; extra wide caterpillar tracks having a width of 42 in. and a bearing area of 111 sq. ft. are available when necessary, enabling the machine to travel over very soft ground. A fully illustrated catalogue describing the machine can be obtained on application to the makers, Ruston-Bucyrus, Ltd., Lincoln.

The Portland Cement Industry in Spain.

By ADRIAN MARGARIT.

THE vitality of the Portland cement industry in Spain has been shown during the last few years by a number of circumstances, both favourable and adverse. During the Dictatorship an impetus was given to public works and several schemes were approved which entailed the consumption of large quantities of Portland cement, with the result that the construction of new cement mills and the improvement and extension of existing mills were put in hand. In less than two years the capacity of the Spanish Portland cement industry increased from less than a million and a half tons per year to two million and a half.

Amongst the new installations examples may be found of modern tendencies towards reduction in cost and improvement of production. Thus, the new mill erected at Córdoba by the "Asland" Company, a description of which was given in the January number of this Journal, and the extensions at the "Rezola" (San Sebastián) and "Hispania" (Castillejos, Toledo) mills are examples of the new "Lepol" system; the Asland mill at Villaluenga (Toledo), where a new dry-process kiln of American manufacture (Allis-Chalmers) was recently erected, has aimed at greater economy in production through the installation of Edge Moor waste-heat boilers, which produce steam sufficient for the production of all the electric power required by the mill. Other mills, still in course of erection, have adopted the Andreas-Krupp system. The wet process mills have also made improvements with a view to more economical production, such as the atomisation of the slurry at the feed end of the kiln. These improvements are reflected in an increasing improvement of quality; several brands of "high-strength" cement are now marketed, and the quality of normal cements has been so improved that several of them exceed the minimum requirements of the 1930 Specification for high-strength cement.

The revision of Spanish Specifications (see CEMENT AND CEMENT MANUFACTURE, June, 1930) is an additional proof of the fact that quality has been improved, while at the same time attention has been given to increasing production and to economy of manufacture. But the end of the Dictatorship resulted in a restriction of public works, and this, together with the present world conditions, has so reduced the demand for cement that consumption now scarcely exceeds one and a quarter million tons, or half the total capacity of the existing mills. This sudden contraction of the market, at a time when there is practically no export trade, coincides with a period of social unrest, rises in salaries, the price of coal, and machinery (especially on goods coming from abroad owing to the depreciation of the exchange), and the restriction of banking credits and scarcity of funds.

The position was met by a quota scheme by which orders were allocated to the various manufacturers according to their capacity; it was felt desirable that these allocations should be made by an independent umpire, and Herr Otto Schott, who was appointed to decide the capacities of the different plants, issued his report at the end of last year. In order that the commercial possibilities or the efficiency of the selling organisations of each company should be taken into consideration, besides the producing capacities, the selling prices for each mill during the years 1929 and 1930 were taken as a basis. With these two factors known it was possible to produce formulas by which each manufacturer was assigned a percentage of the cement orders throughout the Peninsula.

There is no control over selling prices, which are only governed by the law of supply and demand, but there is an arrangement under which those manufacturers who exceed their quota compensate those who have not reached it. This arrangement has the advantage that it automatically localises the sales, thus reducing unnecessary transport costs, which in such a mountainous country as Spain are very expensive. Export sales are free, and submitted to no control whatever.

As a result of this selling policy cement prices have hardly altered, and the very slight increases that have been made do not compensate for the rise in salaries and wages, the increased price of fuel, and restrictions on output. The decrees issued by the Republic prevent speculation.

The export trade of Spain, which began with restrictions in the home market and which has been encouraged by the fall of the Spanish currency, is still of little importance. It is, however, being organised, and there are already African and American markets where Spanish cements are making their appearance.

These signs of vitality and the prospects in Spain for the use of cement in roads, dams, reservoirs, canals, ports, bridges, public buildings, and so forth suggest that, in spite of the critical times which the Portland cement industry is going through, a successful future is open to it in Spain as well as abroad.

Scheme of Analysis for Cements.

THE following is an extract from *Zement*, p. 987, 1931, by H. Burchartz. Various suggestions have been made for modifications of the scheme of analysis issued in conjunction with the new German specification. These have been investigated by the Analysis Committee and it has been decided that modification is only necessary in the method for determining alkalis, for which the following procedure is now recommended. SiO_2 is removed by a single evaporation with HCl . $\text{R}_2\text{O}_3 + \text{CaO}$ is removed from the filtrate by ammonia and ammonia oxalate. The filtrate is reduced to 50 c.c. and small amounts of ammonia and oxalate are again added and any precipitate filtered off. This above is carried through with two separate grammes of cement. The two filtrates are now united, taken to dryness, and the ammonia salts expelled. The residue is taken up with a minimum of water. The M_2O is precipitated in the cold with strong Ba(OH)_2 solution (0.2g Ba(OH)_2 in 5 c.c. H_2O per 1g cement); stand half an hour, filter, and wash three times with a very little 5 per cent. Ba(OH)_2 . The excess Ba(OH)_2 is removed by $(\text{NH}_4)_2\text{CO}_3$, and the filtrate is decanted boiling from the BaCO_3 , which is finally washed out with water. The filtrate is taken to dryness and heated in an oven at 130 deg. C. The residue is moistened with HCl , the excess HCl is driven off and the residue weighed. The weight is multiplied by 0.6317 to give the alkalis calculated as K_2O .

If it is desired to separate the alkalis the chlorides are dissolved in water and twice evaporated down with perchloric acid. Alcohol containing a little perchloric acid is added to the residue when cool, and KClO_4 separates on stirring. This is filtered on the pump into a weighed glass filter crucible, washing with alcohol. The crucible is dried at 130 deg. C and weighed. Weight of $\text{KClO}_4 \times 0.3399 = \text{K}_2\text{O}$; Na_2O by difference.

Properties of Portland Cement Particles Smaller Than 10 Microns.

MR. J. H. JENNINGS, B.Sc., A.R.C.S., Chief Chemist of Australian Cement, Ltd., writes:—

It is often said that particles of cement flour smaller than 10 microns are useless in cement, either because they are too rapidly hydrated or because they are covered with an air film. These do not seem very good reasons, although seemingly good enough to support the superstition. The fact that finer grinding in the usual mills does not improve the strength so much as might be expected has led to a considerable acceptance of the idea, although it has never been properly established.

Having some air separators at my disposal, I have endeavoured to subject the matter to experiment. The first experiments were made with the standard air elutriator. Ordinary cement of very high quality, as usually made at my factory at that time but not with the exceptionally rapid hardening qualities of the special cement made there, was used. The flour obtained was quick setting, although it contained 1.85 per cent. of SO_3 . Briquettes were made by the standard Australian method and gave the following tensile strengths (1:3 standard sand): 4 hours, 98 lbs. per sq. in.; 16 hours, 422 lbs.; 24 hours, 443 lbs. The obscurometer size was 11 microns, but the real average size was much less.

Another flour measured 9 microns in the same instrument and gave 314 lbs. at 16 hours and 430 lbs. at 24 hours, using cold water to overcome the quick set.

A larger sample of flour was then obtained and some 4:2:1 (by weight) concrete, with 2 in. slump, and $\frac{3}{4}$ in. maximum aggregate size, made from it into 6-in. cubes. These broke at 2,659 lbs. at 24 hours and 4,000 lbs. at 3 days. The obscurometer size was 11 microns, but measured under the microscope the size was less than 7 microns.

After these tests were made, I had the opportunity of using a Federal air separator, with which products of various sizes can be obtained by using diaphragms of different sizes, and nearly all the flour between certain sizes can be separated. The finest flour was obtained from the same cement, by using the 2-in. and $\frac{1}{4}$ -in. diaphragms. It had 6.8 per cent. loss on ignition and 6.6 per cent. SO_3 . A pat made with 41.7 per cent. water (normal consistency) had an initial set of two hours, and it was hard in three hours. The high loss on ignition was in part due to the need for blowing much air through it because the cement has to be passed many times through the instrument to remove all these fine particles.

A 3:1 briquette using 13 per cent. of water gave 450 lbs. at 17 hours; the high strength considering the large amount of water used is noteworthy. A repetition of this produced flour measuring 7 microns in the obscurometer and 3 microns under the microscope, with 6.5 per cent. loss on ignition and 7 per cent. SO_3 . This gave the following strengths in lbs. per square inch:

Age	16 hours	24 hours	2 days	3 days	7 days
3:1 tensile test, 13 per cent. water	450	520	—	550	610
6:1 6-in. concrete cubes, 13.2 per cent. water, $\frac{1}{4}$ -in. aggregate	1,868	1,950	2,530	2,531	—

A sample of the flour which escaped from the machine but was caught in the attached stocking measured seven microns in the obscurometer and two under the microscope. This sample was the most remarkable of all. It contained 9.8 per cent. of SO_3 , 11 per cent. on ignition, and normal consistency required 90 per cent. of water. A 3:1 compression cube made with 18 per cent. of water gave 4,689 lbs. at 24 hours.

These tests are sufficient to prove that the very finest particles of cement give the greatest strength. As mentioned, the sizes are separated by using different diaphragms, and separation is continued until no more comes over with a given pair. This allows one to get an idea of the proportions of the constituents. The following table, although not complete, may be interesting:

Diaphragms	1/4	5/16	6/16	7/16	8/16	9/16	10/16	11/16	12/16	13/16	14/16	15/16	Residue
Percentage of total weight ..	0.8	1.1	1.4	4	16	33	10	7	4	9	9	3	1.7
Tensile strength													
3:1, 24 hrs.	564	580	434	500	364	104	nil	nil	nil	nil	nil	nil	nil
28 days ..	N.D.	N.D.	734	630	536	500	440	416	300	234	250	N.D.	N.D.
Percentage of water	12	11.5	11.5	11.0	9.0	9.0	8.5	8.5	8.5	8.5	8.5	—	—

These figures show that in order that finer grinding shall be really effective, and I suppose that nowadays nobody thinks much of anything but early tests, it must largely increase the amount of flour that is separated by the 7/16 diaphragms and under. Apparently finer grinding is rather disappointing because the 8/16 and 9/16 flour is increased, but the amounts of the other fines are not much increased. A more complete investigation would test this.

Although I do not attach much importance to the obscurometer, and in fact consider it misleading, it may be of interest to say that the sizes given by it to the 7/16, 8/16, 9/16, 10/16, 11/16 fractions were respectively 10, 14, 24, 38, and 44 microns.

It seemed to be a matter of interest to see if the finest particles of cement have the same composition as the coarser ones, and at the same time to see if the great strength developed by these particles is due to their size or their composition. There may be a preferential grinding of the clinker crystals. Clinker consists of different crystals and magmas mixed together, and of different compositions which may grind differently, at least to some extent; for example, the more highly limed parts may give a fine product more readily than those lower in lime as is generally supposed, and if this is the case separating and analysing the finest parts ought to prove them different from the original cement.

The strengths shown by the finest fractions are so great that the different strengths of different cements might easily be due more to differences in the grinding than in composition, or even in anything else. To say that with equally sound cements the higher lime gives the greater strength does not give much helpful information, as the other conditions have also changed. It is generally more economical to run with a low lime content, and it should be useful to know if the particles of a low-limed cement have approximately the same strength as those of the same size of a higher-limed one, because if they have

it is more important to attend to the physics of clinker grinding than to the chemistry of clinker composition.

Cement A, made in New South Wales, was first used to determine this point. The cement was first put through an A.P.C.M. standard air elutriator and showed 61.9 per cent. of flour. The compositions were as follows:

	Cement.	Clinker Corresponding.	Residue.	Clinker Corresponding.
SiO ₂	23.36	24.60	24.82	25.00
I.R.	0.28	—	0.34	—
Al ₂ O ₃	6.66	7.06	7.54	7.68
Fe ₂ O ₃	1.46	1.55	1.54	1.56
CaO	62.44	64.88	63.70	64.40
MgO	1.27	1.35	1.12	1.20
SO ₃	1.74	—	0.15	—
Loss	2.30	—	0.59	—

These figures indicate a slight change of composition.

Treated in a similar way, a sample of cement B, made in Victoria, gave the following results:

	Cement.	Clinker Corresponding.	Elutriator Residue.	Clinker Corresponding.
SiO ₂	21.36	22.08	21.62	21.90
I.R.	0.62	—	0.94	—
R ₂ O ₃	8.58	8.88	8.96	9.08
CaO	66.02	67.35	65.96	66.89
SO ₃	1.23	—	0.12	—
Loss	0.57	—	0.16	—

A slight change of composition is also indicated here. This elutriator takes away about half the cement. Any change would be more definitely shown by an analysis of the very finest portion. The Federal air separator allows this to be done. By using diaphragms of different sizes sharp separations into different micron sizes can be obtained. In this case the $\frac{1}{4}$ in. diaphragm was used, separating about 10 per cent. of the finest part, which would be all under 10 microns. The analyses were:

	Flour.	Corresponding Clinker.	Clinker corresponding to original cement.
SiO ₂	19.32	22.38	24.60
I.R.	0.33	—	—
Al ₂ O ₃	6.20	7.19	7.06
Fe ₂ O ₃	1.46	1.69	1.55
CaO	60.27	66.60	64.88
MgO	1.10	1.34	1.35
SO ₃	4.00	—	—
Loss	6.58	—	—

The difference between the clinker corresponding to the flour and the clinker it originated from is marked. It appears then that two different clinkers at least were mixed together to make this cement, or different lumps of the same batch of clinker varied 2 per cent., or the different components of the clinker are to some extent separated by the air-separator. In any case, it is plain that the higher lime gives the most readily ground material. Cubes of 70 mm. made of this flour with three parts of standard sand, according to the Australian specification, using 13 per cent. of water (on account of the large amount taken for normal consistency), crushed at 3,878 and 5,676 lb. per sq. in. at 24 and 72 hours respectively.

A sample of flour of cement B made some years ago was obtained in exactly the same way, and gave the corresponding strengths of 5,165 and 6,953 lb. This flour had the composition:

		Flour.	Corresponding clinker.
SiO ₂	17.94	21.00
I.R.	1.24	—
R ₂ O ₃	7.28	8.53
CaO	60.90	68.20
MgO	1.09	1.28
SO ₃	3.94	—
Loss	6.62	—

Comparison between these two is reasonable as the particle sizes must be nearly the same in each case, as is also the extent of aeration and the contamination with gypsum, and these two examples show roughly how the strength varies with the lime. It is not pretended that such a limited test is at all conclusive, and, indeed, the result is to some extent not in agreement with my experience, as I have found on several occasions in testing cement on the plant that raising the lime content 1 per cent. has very little effect on the strength, but these results are reported in the hope that they may show how much more useful flour tests are if the flour is actually collected and tested.

A further test was made separating the same fraction in exactly the same way from a sample of rapid hardening Portland cement. The composition of the flour was:

		Flour.	Corresponding calculated Clinker.
SiO ₂	19.20	21.70
I.R.	1.04	—
R ₂ O ₃	7.30	8.20
CaO	62.65	67.80
MgO	1.46	1.66
SO ₃	4.55	—
Loss	3.27	—

This is similar in composition to the previous one but considerably less aerated, and gave the correspondingly greater strengths of 6,527 and 8,997 lb. at 24 and 72 hours respectively. This result shows the advantage of keeping down the aeration of the finest parts, and why finely ground cements easily fall off in early strength.

United States Cement Production and Sales.

The production of Portland cement in the United States from January to December, 1931, is given by the United States Bureau of Mines as 124,594,000 barrels, compared with 160,905,000 barrels in 1930. The sales in 1931 were 126,465,000 barrels, compared with 158,744,000 barrels in 1930. The percentage of production to capacity was 46.5 in 1931, compared with 61.5 in 1930. The number of plants in operation in both years was 165.

Extension of United States Plant.

We understand that the Marquette Cement Manufacturing Company is enlarging its plants at Cape Girardeau, Mo., and La Salle, Illinois, at a cost of 500,000 dollars (£102,880).

Absorption of Water by Cement.

THE object of a recent research by Messrs. P. Hänsel, R. Steinherz, and C. L. Wagner was to investigate the setting of cement by centrifuging cement pastes during setting and studying the separated solutions and thickened pastes. Particular attention was paid to the amount of water absorbed by the cement. A report published in *Zement* deals with the first stage of a comprehensive research which is in progress.

(1) After a number of trials of different centrifuges, a centrifuge was constructed having four buckets of about 200 c.c. capacity each, and capable of various speeds of revolution between 1,100 and 2,600 revolutions per minute. The rate of enforced sedimentation was thus between 200 and 1,000 times that due to gravity. In the experiments 100 g. of cement was mixed with w g. of water and placed in the centrifuge bucket, which was then weighed (weight of paste = G). Mixing the cement and filling the bucket took five minutes, and it was found that a slight variation in this period was unimportant. The time of centrifuging, t , was between five and thirty minutes, after which the separated liquid was removed. The loss in weight, v_0 per 100 g. cement, was calculated and plotted against the time of centrifuging for various additions of water w .

(2) A high-strength rotary kiln cement, A_1 , was first investigated, of normal consistency 29 per cent. In the first experiment ($w=30$ g. water) 3.7 g. solution was separated by centrifuging. To a first approximation the density of the solution was taken as equal to that of water, so that v_0 g. = v_0 c.c. Thus, the water W remaining in the paste was

$$W = (30.0 - 3.7) = 26.3 \text{ c.c.}$$

It might be concluded that with 45 per cent. of mixing water $45.0 - 26.3 = 18.7$ g. solution would be obtained, etc., but this was not the case. The amount of solution obtained increased at a higher rate than that given by this relation, and approached a limiting value asymptotically as shown by Fig. 1. Varying the period of centrifuging between five and thirty minutes had no effect on v_0 and W .

Tests were next made on a shaft kiln cement B, a high-strength shaft kiln cement C, an iron-Portland D, a blast-furnace cement E, and two fused cements F and G. Table I shows the average values of W obtained. It is seen that, in

TABLE I.
 W , average values.

w	A_1	B	C	D	E	F ₁	G
30	26.3	26.0	26.2	26.6	27.3	26.6	25.6
45	33.8	32.6	32.9	32.4	35.4	34.5	31.4
60	36.9	36.6	38.4	37.4	39.2	39.2	33.5
75	—	39.2	—	—	41.6	—	—
90	39.0	39.4	43.6	40.6	41.6	39.6	35.3
105	—	—	—	—	41.7	—	—
120	39.7	—	44.4	40.8	41.9	40.6	35.0

spite of the different chemical compositions of these cements, the absorption of water is practically the same in all cases. It must not be concluded that the variations in the values of W at higher water contents are due to differences in composition (see Section 5). The similarity of the W - w curves for these cements is seen in Fig. 2; to separate these curves the origins of co-ordinates have been displaced along the line AG.

(3) It was found that the paste remaining after centrifuging became more liquid on mixing with a spatula. The effect of giving the thoroughly mixed paste a further five minutes in the centrifuge was therefore tried, and as a result a further portion of solution was separated. This can be repeated several times, obtaining ever smaller quantities of solution until finally no more is obtained.

For example, in the case of a high-strength rotary cement A_2 , with $w=90$ g. water, the following quantities of solution were obtained successively by centrifuging seven times:—

$$49.6 + 7.2 + 4.6 + 3.1 + 1.6 + 1.0 + 0.0 \text{ g.} = 67.1 \text{ g.}$$

$$22.9 \text{ g. water remained in the paste (= } W').$$

The experiment was completed in two hours, i.e., before initial set. The experiment was repeated for various water additions, and it was found that the water content of the paste after repeated centrifuging, W' , was a constant for the

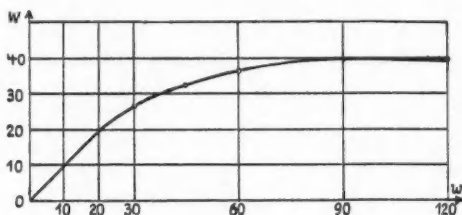


Fig. 1.

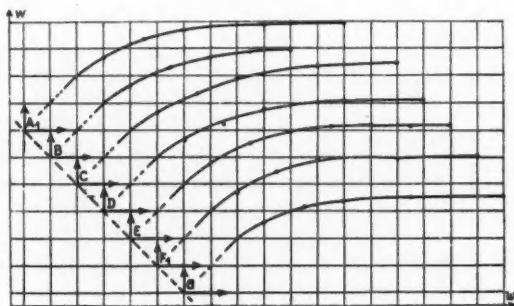


Fig. 2.

cement. Physically, it corresponds to the closest packing of the cement particles, whereby the intergranular space R_1 is a minimum. It may be said that W' (in grammes) $= R_1$ in c.c. $= 23$. The intergranular space, R_2 , when the cement was centrifuged without water, was 33 c.c.

This behaviour of cement was compared with that of standard sand. W' , determined as above, was 23.4 c.c. On centrifuging without water R_2 was 23.2 c.c., i.e., $R_1 = W' = R_2$. It is seen from Section 5 that this difference between the cement and sand is due not to the difference in chemical reactivity but to the coarser grading of the sand.

(4) The results of Section (3) led to the measurement directly of the volume of the cement paste, E , after centrifuging. For a single centrifuging it was found

that $(E - W)$ was a constant, irrespective of the quantity of mixing water used. For cement A_2 the value was 34.1; for a fused cement F_2 , 32.4. These are approximately equal to the volumes actually occupied by 100 g. of the cements as calculated from the density; e.g., $A_2 = 100/3.08 = 32.5$ c.c.; $F_2 = 100/3.26 = 30.7$ c.c. This represents the stage before the cement grains are not yet appreciably surrounded by a new phase (gel) of different density.

TABLE II.

w	(I) A_2 + Water.			(II) A_2 + Oil.			(III) Sand + Water.			(IV) Sand + Oil.		
	E	W	$E - W$	E	W	$E - W$	E	W	$E - W$	E	W	$E - W$
30	59.6	27.4	32.2	—	—	—	68.0	28.0	40.0	—	—	—
45	66.9	36.4	30.5	65.5	33.7	31.8	70.6	33.8	36.8	71.9	34.5	37.4
60	69.7	38.5	31.2	69.2	37.8	31.4	73.9	36.6	37.3	73.2	37.3	35.9
90	73.1	40.7	32.4	71.4	40.1	31.3	78.2	39.6	38.6	77.3	40.3	37.0
120	71.8	39.8	32.0	75.5	43.7	31.8	78.2	38.2	40.0	78.0	41.3	36.7
Average			31.7			31.6			38.5			36.8

(5) The behaviour of cement and ground standard sand was next compared. In addition to water, paraffin oil was used for mixing so as to eliminate the chemical action of the cement. The sieve analyses were: high-strength cement A_1 , 3.0 per cent. residue on 180 sieve, 7.9 per cent. on 250 sieve; ground sand, 3.2 per cent. on 180, and 15.0 per cent. on 250 sieve. Table II and Fig. 3 show the results obtained. In the case of the oil used for mixing, volumes are given instead of weights. Again, w , E , and W respectively represent the volume of mixing liquid, the volume of paste after one centrifuging, and the volume of liquid remaining in the paste.

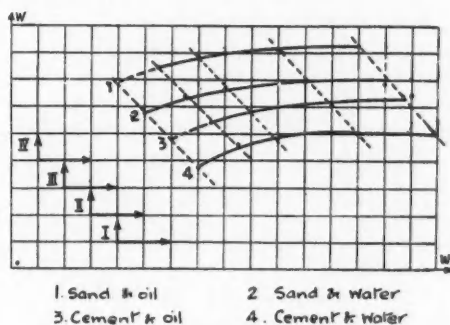


Fig. 3.

The behaviour of cement and sand is seen to be practically the same in both water and oil. $(E - W)$, for cement and sand respectively, has the same value in cement and oil. The values of $(E - W)$ agree well with the values of the space occupied by the powder as obtained from the density, viz., for the cement 31.6 and for the sand 36.8 c.c. per 100 g.

The behaviour under repeated centrifuging was similar to that already described, for both cement and sand in either oil or water. In both cases it was found that, irrespective of the nature of the mixing liquid and of the quantity of

liquid used, $E' - W' = E - W$, where E' is the volume of the paste and W' the volume of liquid retained by the paste after repeated centrifuging. It is thus seen that even two hours after mixing cement and water no measurable quantity of a new phase is formed.

(6) It next appeared desirable to investigate the effect of the fineness of grinding of cement on the water absorption. Cement A was obtained ground to the following residues on the 180 sieve: 5, 10, 15, 20, and 25 per cent. Only the first and last of these are discussed, as the results of the others were intermediate. With a single centrifuging it was found that there was a definite but not very great effect of grain size on water absorption. W diminished somewhat as the cement became finer (e.g., with $w=30$ c.c., W diminished from 25.9 to 25.3; with $w=120$ c.c., from 42.8 to 38.9).

On repeated centrifuging, the minimum quantity of water in the paste, W' , decreases with increased fineness (from 19.2 to 17.9 c.c.). The volume of the actual cement in the paste ($E' - W'$), however, is independent of fineness.

(7) The preceding sections have dealt with experiments in which centrifuging took place soon after mixing. The phenomena when setting is actually interrupted, using cement A_2 with 45 and 90 per cent. water additions, are now enquired into. In Table III the column headed t gives the number of minutes

TABLE III.
Cement A_2 . One centrifuging.

t	$w = 45$	$w = 90$
	W	W
5	34.1	43.4
60	34.3	—
120	34.4	43.8
180	35.7	45.1
240	37.9	44.6
300	39.5	48.3
360	43.7	50.5
435	45.0	—

which elapsed between mixing and centrifuging. As anticipated, the amount of water retained by the paste increases considerably during the period in which it remains undisturbed. In the first two hours after mixing there is no great increase in W , which confirms the accuracy of the preceding experiments.

(8) An experiment in which $w=250$ indicated that hydration proceeds much further with such high water contents than in the case of ordinary mortars. Experiments on 1:3 standard sand mortars were next undertaken. Repeated centrifuging gave a homogeneous paste containing 12.7 per cent. water; this minimum water content must be considered to be definitely and firmly held by the cement-sand mix. The resulting paste corresponds to a plastic mortar. The experiment appears to throw doubt on the method of testing, using earth-moist mortars with only about 8 per cent. mixing water.

(9) This section deals with the correction of the previous results necessitated by assuming the density of the separated solution to be equal to that of water. The correction is appreciable, but not important.

(10) The chemical composition of the solutions separated from Portland cement A_3 and fused cement F was investigated by electrical conductivity measurements and by determination of the basicity and residue on ignition. It

appeared that the solution obtained from A_3 by a single centrifuging only five minutes after mixing was a highly supersaturated solution of $\text{Ca}(\text{OH})_2$ plus CaSO_4 . Conductivity, basicity and residue on ignition were not affected by the fineness of grinding of the cement, but were greatly dependent on the amount of mixing water used, diminishing as the quantity of water was increased. The residue on ignition was much higher than was to be expected from the conductivity and basicity measurements, which indicated the presence of colloids in addition to true supersaturated solutions.

The results for the fused cement were entirely different from those for the Portland. Both conductivity and basicity measurements gave values which showed that the solutions were not nearly saturated.

(11) Chemical analyses were made of various solutions. For example, the solution centrifuged five minutes after mixing from a cement paste containing 45 per cent. water gave 0.1 mg. SiO_2 , 1.8 mg. R_2O_3 , 51.4 mg. CaO , 532.5 mg. K_2O , 28.1 mg. Na_2O , 364.0 mg. SO_3 per 50 c.c. Calculation shows that these solutions are essentially alkaline alkali sulphate solutions. The analyses show also that solution is obtained very rapidly in the cement paste, and that the concentrations of the dissolved substances change only very slightly after the first five minutes. A programme of systematic analyses of such solutions will form part of the future work.

Portland Cement with the Maximum Possible Lime Content.

In *Zement*, pp. 882, 904, 1931, Herr M. Hess states:—

It is shown that a cement based on the formula $3\text{CaO} \cdot \text{SiO}_2 + 3\text{CaO} \cdot \text{Al}_2\text{O}_3 + 3\text{CaO} \cdot \text{Fe}_2\text{O}_3$ is not usually sound. It is suggested that a sound cement of this formula can be obtained by replacing the ground limestone in the raw mix by slaked lime, thus increasing the internal surface of the mix by ensuring that all constituents are colloidal. Experimental cements of lime saturation factor (L.S.F.) above 100 were burnt in a coke-fired laboratory shaft kiln, using a mix of slaked lime and clay. A cement of L.S.F. 103 proved perfectly sound, although the ratio of tensile to crushing strength was too low. It is thus shown that there is no sharp limit for maximum lime content, and that the theoretical value given by L.S.F. 100 can be exceeded in practice. The maximum CaO content can be attained by (1) fusing, (2) increasing the flux, and (3) increasing the surface of the raw mix; the last appears best. The technical details for producing a cement of L.S.F. 100 should be worked out. The great objection to the slaked lime process is that the raw slurry requires much more water (possibly almost twice as much) than the normal. Filtration may, however, overcome this. Advantages of the process are that less power is required for grinding, the kiln could be shortened by 24 to 30 per cent., there is no CO_2 to drive off, and clinkering is easier. Kühl's L.S.F. forms an excellent criterion for adjusting lime content.

In Vol. 20, p. 950, of the same journal, Dr. Steiner agrees with Hess that it is possible for the lime saturation factor of Portland cement to exceed 100. In practice, however, the slaked lime process is hopelessly uneconomical unless waste lime is available. Parallel tests with lime and a normal mix, extending over two weeks, showed that the slurry containing lime requires 55 per cent. water for pumping as against 35 per cent. for the normal slurry. The coal consumption was enormously increased (from 4,100 to 5,400 B.T.U.s per lb. clinker), while the output of clinker was reduced. The steam developed in the waste-heat boiler was reduced by 60 per cent. If a filter was used the cake was too soft to handle.

Multi-chamber Mills with Air Separation for Superfine Cement.

By A. B. HELBIG.

THE demand for superfine cement is increasing in all industrial countries, especially owing to the present general economic crisis which demands exceptional efforts in order to meet competition. The writer's theory that superfine cement cannot be economically produced in tube mills of the one-pass grinding method has been strenuously contested, but without reaching any decisive issue. One reason for the inefficiency of the compartment mill is that after a certain degree of fineness has been reached, small cement flakes are produced in the finishing compartment. Another is that, owing to electro-static tensions being present between the grinding bodies, many ground materials adhere to the steel balls, etc., and coat their total grinding surface, thus decreasing their grinding power. Also, in long mills of the one-pass grinding type, the material to be treated becomes heated to such a high degree that, when producing cement, for instance, the added raw gypsum is more or less calcined, thus unfavourably affecting the setting time of the cement. Furthermore, the heat which is generated in the material and by the grinding bodies represents an undesirable expenditure of energy, which amounts to one kcal for 424 kg/m.

The correctness of these statements is confirmed by the German Patent No. 519308 of Carl Pontoppidan, of Copenhagen, which protects a method of treating cement and similar materials under the introduction of cooling means. As of particular interest, mention should be made of page 1, lines 8 to 21: "If the temperature in one part of a grinding mill in which cement is ground exceeds 100 deg. C., then the ground material will show to a greater or lesser degree an inclination to adhere to the grinding media and to other surfaces with which it comes into contact during the grinding process, whereby the efficiency of the grinding agents is lessened, so that at higher temperatures the same quantity of material cannot be ground to the same degree of fineness as at lower temperatures when the material does not stick to the grinding bodies."

Lines 33-50 on the same page are of interest: "Apart from the drawback of adherence of the material to the grinding bodies and other surfaces, the rise of temperature in the mill during the grinding process can also bring about other grave results. For example, cement which has been exposed in the above manner to a rising temperature during the grinding process shows a substantially shorter setting time than is admissible for non-blowing standard cement, so that the temperature rise also influences adversely the quality of the cement in a direct manner."

A direct suggestion for air separation can be read from lines 27-30 on page 2: "... that the temperature of the material during the last phase of the grinding process, where a reduction of the temperature is of highest importance, rises in such a degree that the above-mentioned drawbacks occur."

The patent protects the introduction of a cooling agent which shall evaporate at the temperatures produced within the mill during grinding. Special attention should be drawn to the German Patent No. 521721 of Messrs. Carl Pontoppidan, Holte, and Svend Buntzen, of Copenhagen, who state on page 1, lines 33-48: "A careful study of the conditions has led to the recognition of the fact that the drawbacks are principally due to thermal conditions which occur in the mill and which result in gypsum being present in the finished cement either in the

shape of raw gypsum or occasionally as burnt gypsum; this results in variable setting times of the cement taken from the bulk leaving the mill at different points." The patent protects the admixture of gypsum under such conditions that the temperature in the mill can never rise to the burning temperature of gypsum in order to obtain a final product free from calcined gypsum.

In this relation also Patent Application P. 4230, dated March 7, 1930, of Carl Pontoppidan, of Copenhagen, is of interest; the first patent claim is as follows: "Method for dry grinding of cement and raw materials for cement by the aid of metallic grinding bodies to a high degree of fineness, characterised by the combination of admixtures with the material to be ground, which reduce the electrical potential difference brought about by the friction during the grinding process, by increasing the conductivity of the material to be treated between the grinding media and the material to be ground." A better illustration of the difficulties which occur in the production of superfine flour in the mill of the one-pass grinding type cannot be found.

All these drawbacks are eliminated if the material is only ground in the mill to such a degree that the grinding bodies are still effectively grinding and the rise in temperature of the material is not considerable. This can be obtained by the installation of an air separator behind the mill.

The discussions upon the question whether there is a limit to the scientific (not economic) fine grinding of superfine cement, *i.e.*, if the strengths are increased with the higher fineness of the cement, might be decided by the publications of Steiner in "Tonindustrie-Zeitung," No. 46, 1931, page 672, and the publications of Dr. Weissgerber, of Berlin, in Nos. 65 and 66 of the same journal, according to which the present writer's opinion is confirmed that the strengths actually increase with the higher fineness.

It must be taken into consideration that the superfine cement, *i.e.*, the cement with 55 per cent. flour between 0 and 20 microns, represents a comparatively new building material which must be individually treated both in regard to tests for strength and other characteristics. Tests recently made by the author with cement ground in a compound mill have led to very interesting results. From the series of cements analysed by the aid of the Gonell apparatus, 45 per cent. fine powder between 0 and 20 microns has been determined as the average. It should be noted, however, that the results obtained by the Gonell process should be considered with a certain amount of reservation, although all the tests have been conducted so far as is technically possible with the same degree of care and under the same conditions.

One of the cement works sent a cement produced from rotary kiln clinker by the aid of a multi-chamber mill. The screen analysis of this cement with high strength after a short seasoning has shown—

4.0	per cent. residue on the Continental	4,900-mesh sieve.
13.0	" " " " " "	10,000- " " "
18.5	" " " " " "	16,900- " " "

The Gonell tests resulted as follows:

49.68	per cent. in a grain size from	0 to 20 microns.
27.10	" " " " " "	20 " 40 " "
16.61	" " " " " "	40 " 60 " "
93.39	" " " " " "	0 " 60 microns and 6.61 per cent. above 60 microns

This cement was air separated in the testing plant of Gebr. Pfeiffer Barbarossa-werke A.G., of Kaiserslautern (Germany), and four fine cements were produced. viz.: Cement I with traces of residue on the Continental 16,900 mesh, Cement II

and III of the same fineness, and Cement IV with traces of residue on the Continental 10,000-mesh sieve.

TABLE I.
PERCENTAGE OF FINE FLOUR IN A GRAIN SIZE OF MATERIAL.

		0 to 20 Microns.	20 to 40 Microns.	40 to 60 Microns.	Larger than 60 Microns.
Cement	I ..	93.52 per cent.	5.38 per cent.	0.72 per cent.	0.38 per cent.
	II ..	88.36 ..	10.73 ..	0.54 ..	0.37 ..
	III ..	81.63 ..	16.40 ..	0.81 ..	1.16 ..
	IV ..	68.66 ..	30.27 ..	0.77 ..	0.30 ..

Table I, which gives the results of the Gonell tests, illustrates the fine gradua-tions into which the cement of a one-pass grinding mill can be separated. The four cements were returned to the cement works, where the laboratory tests have given the results shown in Table II:

TABLE II.

Cement.	Water Per-centage.	Rise in Tem-perature.	Specific Gravity.	Volumetric Weight.		Setting Time.	
				Without Shaking.	When Shaken.	Initial.	Final.
I	32	3 deg. C.	3.105	Grams. 800	Grams. 1,520	Hours. 2½	Hours. 5½
II	32	3 deg. C.	3.007	860	1,580	3½	7
III	32	3 deg. C.	3.007	900	1,650	3½	6½
IV	32	3 deg. C.	3.175	940	1,700	3½	7

It is remarkable from this table that all the cements are slow setting, a fact which, in my opinion, demonstrates the absurdity of the statement that air separation would cause separation of cement and gypsum. The contrary is proved by the water consumption and the rise in temperature. But it is interesting to note how the volumetric weights of these four cements differ. It might be an interesting field for research to examine the influence of the various grain sizes upon the modifications of the volumetric weights. In Table III are the figures of strength in kg. per sq. cm.

TABLE III.

Age in Days		1		2		3		7		28		Combined Seasoning.	
Cement.		a	b	a	b	a	b	a	b	a	b	a	b
I	27.3	355	38.0	502	36.5	576	40.0	746	45.4	920	52.0	956	
II	28.0	322	34.0	478	36.0	604	42.5	743	45.0	915	48.2	924	
III	26.0	308	33.0	471	36.1	585	41.0	742	45.5	903	48.0	926	
IV	24.5	246	31.8	426	40.0	510	41.5	728	42.2	832	53.0	900	

a = tensile strength. b = compressive strength.

The writer deduces from these figures that in practice it might be of little use to produce a cement with a percentage of more than 70 per cent. flour from 0 to 20 microns, but he invites discussion as to whether it is possible to determine the

maximum strength of superfine cement with the test methods hitherto in use for standard cement. In any case the strengths of superfine cements far exceed the average figures of the cement hitherto produced by one-pass grinding.

In the cement mills under consideration the clinker is fed into the compartment mills in lumps of a size up to 40 mm. Grinding the cement to a fineness with a small percentage of residue on a 4,900-mesh sieve and assuming as an average size of the product the particles going through the 0.088 mm. wide holes of this screen, 730,000 particles of 0.088 mm. diameter would be produced from one lump of 40 mm. diameter. Extreme grinding to this degree in one machine does not seem good practice. Even when grinding a standard rotary kiln clinker, the average size of which can be presumed in normal operations of the kiln to be 10 mm., with clinker of 10 mm. diameter we should obtain 11,400 particles of 0.088 mm. diameter. This example demonstrates the great advantage of an intensive pre-crushing of the feed for fine grinding mills, which has hitherto been greatly neglected.

The study of the patent literature shows that a substantial percentage of all patents regarding tube mills with a number of compartments deal with the separation of the ground material in the first compartment, but without arriving, in the writer's opinion, at any ideal solution of this problem.

The combining of the pre-grinding and fine-grinding processes into one mill results in a simple mill, but at the cost of increased power consumption. It is freely admitted that the dividing of a multi-chamber mill into a pre-grinding and fine-grinding machine appears at first sight as a retrograde step, because this division was already in practice before the invention of the multi-chamber mill. The power saved, however, should justify this apparent retrograde step from an economic point of view, especially when due consideration is given to the fact that the modern development of the cement industry is tending to eliminate small and medium cement-making plants and is concentrating upon large plant units. It should not be difficult to find within large cement-making concerns suitable persons who could undertake with circumspection the working of the somewhat more complicated plants advocated.

According to the present state of the art of grinding, it is the opinion of the writer that the large grinding plants of the future will develop along the following lines. Coarse material will be reduced to a maximum size of approximately $\frac{1}{2}$ mm. by the aid of a pre-grinding apparatus. This pre-grinding apparatus will work on the principle of a circuit grinding in such a manner that the material which contains a relatively high proportion of over-size leaves the pre-grinding apparatus and is fed to an oscillating sieve which separates the material from 0 to $\frac{1}{2}$ mm., the grits from the screen being then returned to the pre-grinding mill. The material of a grain size from 0 to $\frac{1}{2}$ mm. probably already contains a good quantity of fine flour, but it would be a mistake to separate the finest meal. As a separating machine for this purpose, only the oscillating screen should be used, as this is unsurpassed in its economical capacity for a size of grain up to 0.5 mm. The size, however, of a grain of $\frac{1}{2}$ mm. should be elastic both upwards and downwards according to the physical characteristics of the clinker to be ground. By the installation of an oscillating sieve behind the pre-grinding mill, and by inserting the air separator behind the finishing mill, all the disadvantages of the multi-chamber mill are overcome because the ground product is suitably aerated and cooled.

The intermediate material from the sifter should be charged into the fine-grinding mill, the grinding charge of which should be so selected as best to suit the character of the material to be ground. The writer believes, for instance,

that cement should be ground until a residue of between 15 and 30 per cent. is left upon the 4,900-mesh sieve. Out of this relatively coarse cement flour the necessary superfine cement must be separated by air separation and the grits recharged to the fine mill.

For pre-grinding purposes a double hard mill is preferable, whilst for fine grinding only mills with a long grinding surface, such as a multi-chamber mill, should be used, in which the fine flour from the first mill will be further reduced in order to increase to the utmost the percentage of impalpably fine material. The present multi-chamber mill plants for cement should grind the clinker to a rather coarse meal with 15 to 30 per cent. residue on the English coarse sieve. This meal is then treated by air separation.

From the many results of sieving and grinding tests emanating from compartment and multi-chamber mills which have been sent to the author, the diagram in Fig. 1 has been prepared for the purpose of calculating new curves of the expenditure of grinding media per kilo of cement. These curves are plotted upon the basis of the mean values drawn from the mill schemes which were available up to the date on which this article was written. The figures have been calculated as follows: The capacity of the mill is determined by A kg./h. The charge of grinding bodies up to a certain point is calculated to be the average charge. The samples taken at this point are sifted and the residue is determined upon a standard test screen, preferably the Continental 4,900 or 10,000-mesh sieves, corresponding to the 180 and 250 English standard sieves.

The expenditure in grinding bodies per kg. of cement results from the following consideration, and it would seem to be opportune to explain this by means of an example. Assuming that the capacity of a multi-chamber mill for a cement flour having 5 per cent. residue on a sieve of 4,900 meshes to be 10,000 kilos per hour, with a grinding charge of 30,000 kilos for the total length of 12 metres of the mill, then 3 kilos of grinding media are required for 1 kg. of cement with a residue of 5 per cent. on the 4,900-mesh screen. The sample taken at 8 metres from the inlet of the mill shows 15 per cent. residue on the same test screen, but

only $\frac{8}{12} \times 30,000 = 20,000$ kg. of grinding media do this work, and therefore only 2 kg. of grinding media are required for 1 kg. of cement.

From a long series of grinding schemes from compound and multi-chamber mills sent to the author or drawn by him from tests with customer's samples, grinding curves as in Fig. 1 were plotted. These grinding curves have been the basis for a further development of the curves of the grinding bodies per kilo of cement with variable residues on the 4,900-mesh. The series of curves thus obtained from shaft kiln and rotary kiln cements has resulted in diagrams in which the individual lines have crossed each other in variable inclinations and curves. This, however, should cause no surprise if the factors influencing the grinding process are taken into consideration, namely:

(1) The grinding curves of mills by the same manufacturers (only a few curves of each mill could be compared) ran, under the same conditions and with different clinker, nearly parallel, but they were lying at different heights.

(2) The charge of grinding bodies, which varies from 20 to 40 per cent. of the interior capacity, amounted in one case to about 50 per cent. (this latter figure is still being verified).

(3) The grinding media used consisted of balls, flattened balls, cubes of various sizes, cylinders—some of equal length to the diameter and some longer—double balls, and hollow cylinders. This diversity in the grinding media proves that

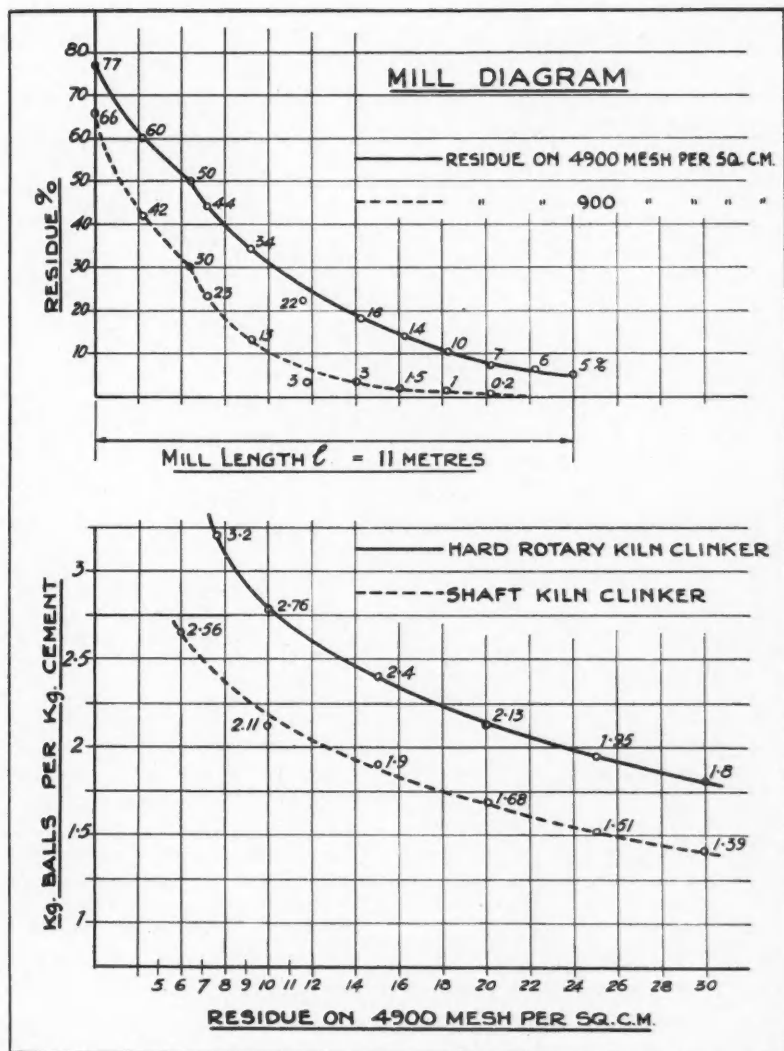


Fig. 1.

there is still room for considerable improvement in the perfecting of the multi-chamber mill, because only a small selection of the grinding media can be regarded as being very suitable and their sizes must be varied to suit the varied degree of fineness of the material to be ground in the separate compartments.

(4) The construction of the linings—step linings, flat steel linings, silix linings, etc.

(5) The shape and construction of the partition walls.

(6) The ventilation of the mill.

(7) The diameter of the mill.

(8) The revolving speed of the mill.

All curves had, however, the common characteristic that with the reduction of the residue below 10 per cent. on the 4,900-mesh screen all the lines were asymptotically running towards the axis of abscissæ, *i.e.*, the requirement in grinding media per kilo of cement rose very rapidly.

In the lower part of Fig. 1 two curves showing the expenditure of grinding media per kilo of cement are plotted as the average value arising out of the existing grinding curves. The upper curve represents the demand in grinding media for very hard rotary kiln clinker, and the lower one was drawn from the grinding curves of first-class shaft kiln clinker. It is curious that both these curves are nearly parallel, but it should be particularly mentioned that this is a chance result in order to avoid drawing incorrect conclusions. Both these curves only apply to the tested cements and are used for the purpose of demonstrating the advantages of air separation behind the multi-chamber mill.

Table IV gives the results of average curves.

TABLE IV.
SHAFT KILN CLINKER.

	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Residue on 4,900-mesh sieve..	6	10	15	20	25	30
Output	82	100	111	126	140	152
Quantity of grinding media per kg. cement.. . . .	2.56 kg.	2.11 kg.	1.9 kg.	1.68 kg.	1.51 kg.	1.39 kg.

HARD ROTARY KILN CLINKER.

	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Residue on 4,900-mesh sieve..	7.6	10	15	20	25	30
Output	86	100	115	129	142	153
Quantity of grinding media per kg. cement.. . . .	3.2 kg.	2.76 kg.	2.4 kg.	2.13 kg.	1.95 kg.	1.8 kg.

The figures of Table IV are now used to demonstrate the improvement resulting from the erection of an air separator behind the cement mill. The expenditure in grinding media for hard rotary kiln clinker ground to a fineness of 25 per cent. residue on a 4,900-mesh sieve amounts, according to this specification, to 1.95 kilos.

By circuit air separation 90 per cent. of fine flour can be extracted from the feed of the air separator.

Feed 100 kgs.	=	25 kgs. grit	+	75 kgs. fine flour.
Separated 90 per cent.	=	67	"	"
Return 33 kgs.	=	25 kgs. grit	+	8
Return 100 per cent.	=	76 per cent. grit	+	24 per cent. fine flour.
For 100 kgs. fine flour	=	$\frac{33}{67} \times 100$	=	50 kgs. return.

This return is already of a very high fineness and only contains small particles, among them 24 per cent. of fine flour passing the 4,900-mesh sieve, which means

that when finishing the tailings or grit the quantity of grinding media required is substantially smaller than for the feed itself. If, however, this fact is neglected, and the same expenditure in grinding media used as a basis, the calculation would be of a very reliable nature.

As 75 per cent. of fine flour is contained in the ground material and 1.95 kgs. of grinding media have been required at 25 per cent. residue, the expenditure in grinding bodies amounts to $\frac{1.95}{0.75} = 2.6$ kgs. for a product with 100 per cent. fine flour or with no residue on a 4,900-mesh sieve.

The one-pass grinding shows, for a flour with 10 per cent. residue on a 4,900-mesh sieve, 2.76 kgs. of grinding media, and this figure rises to 3.2 kgs. when grinding to 7.6 per cent. residue. The reduction of the power consumption and the increase in output after the erection of the air separator is of much importance for superfine grinding.

According to Table IV the quantity of grinding bodies required for 1 kilo of cement with 10 per cent. residue on a 4,900-mesh sieve amounts to 2.76 kgs. for rotary kiln clinker, and 2.11 kgs. for shaft kiln clinker.

After the separation of the grit 0.9 kg. of fine flour with 0 per cent. residue remain, and starting from a ground material with 10 per cent. residue the expenditure in grinding bodies for 1 kg. of flour with no residue would therefore be $2.76 : 0.9 = 3.07$ kgs. for rotary kiln clinker, and $2.11 : 0.9 = 2.34$ kgs. for shaft kiln clinker.

The continuation of this consideration on the basis of Table IV leads up to the figures shown in Table V.

TABLE V.

ROTARY KILN CLINKER.			SHAFT KILN CLINKER.		
Ground Material.		Fine Flour 0 per cent. Residue.	Ground Material.		Fine Flour 0 per cent. Residue.
Residue on 4,900-mesh Sieve.	Quantity of Grinding Media.	Quantity of Grinding Media.	Residue on 4,900-mesh Sieve.	Quantity of Grinding Media.	Quantity of Grinding Media.
7.6 per cent.	3.20 kgs.	3.46 kgs.	6 per cent.	2.56 kgs.	2.72 kgs.
10 "	2.76 "	3.07 "	10 "	2.11 "	2.34 "
15 "	2.40 "	2.82 "	15 "	1.90 "	2.24 "
20 "	2.13 "	2.68 "	20 "	1.68 "	2.10 "
25 "	1.95 "	2.60 "	25 "	1.51 "	2.01 "
30 "	1.80 "	2.57 "	30 "	1.39 "	2.00 "

Table V demonstrates that with higher degrees of fineness of the ground material, from which the fine flour is extracted, the demand in grinding media per kg. increases, and that therefore the power consumption is also rising. According to these figures the intermediate air sifting should be arranged for the material to be ground between 20 to 25 per cent. residue on the 4,900-mesh sieve; if the ground material is too coarse the proportion of returned tailings would be too great.

The importance of air separation for fine grinding is further demonstrated by the following test results (Table VI) of a multi-chamber mill of first-class construction, showing the expenditure in grinding media for rotary kiln cement.

TABLE VI.

Residue on 4,900-mesh Sieve.	Clinker Quality.	Quantity of Grinding Media.
1.7 per cent.	Standard	4.50 kgs.
2.0 "	Hard burnt	5.00 "
4.2 "	Standard	2.82 "
5.0 "	Hard burnt	2.90 "
9.2 "	Hard burnt	2.65 "

It is shown from these figures that the finest cement can only be economically produced by installing the air separator behind the compartment mill.

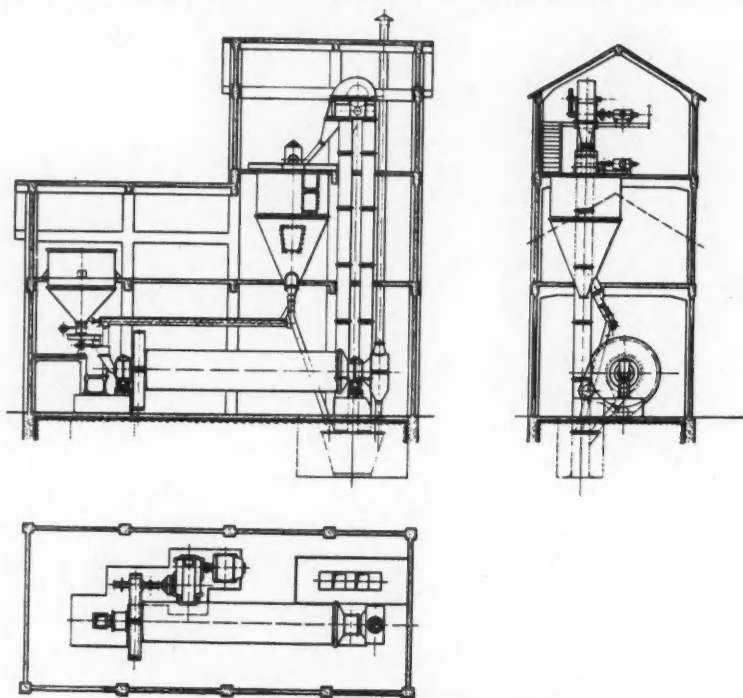


Fig. 2.—Multi-chamber Mill with Air Separators.

A calculation based upon the grinding curve of a multi-chamber mill 2.2 metres diameter by 11 metres long has shown that rotary kiln cement with 1.7 per cent. residue on the 4,900-mesh sieve and 7 per cent. residue on the 10,000-mesh sieve requires grinding bodies of 4.5 kgs. and 1.9 kgs. at 21.8 per cent. residue on the 4,900-mesh sieve, and 30.8 per cent. on the 10,000-mesh sieve. If the



**Klöckner-Steel Balls and Steel Rolls
(Cylpebs),**

made of special steels with great natural hardness as, e.g., special open - hearth steel, chromium steel, chromium-molybdenum steel, silicon steel and manganese steel.

Klöckner-Werke A.-G.

Georgs-Marien-Hütte, Osnabrück,
Germany.

latter coarse material is charged into the air separator in order to separate a material having 7 per cent. residue upon the 10,000-mesh sieve, the calculation in Table VII results:

TABLE VII.

10,000-MESH SIEVE.

Feed 100 kgs.	=	69.2 kgs. fine flour	+	30.8 kgs. grit.
Separated 90 per cent.	=	62.2 " "	+	4.5 " (0.07 × 62.2).
Return 33 kgs.	=	7.0 " "	+	26.3 " "
Return 100 per cent.	=	21.0 per cent. fine flour	+	79.0 per cent. grit.
Fine flour 66.7	=	62.2 kgs. " "	+	4.5 kgs. " "

The production of 100 kgs. of cement with 7 per cent. residue on the 10,000-mesh sieve requires 150 kgs. of ground material with 30.8 per cent. residue on the same sieve; the return amounts to 50 kgs. with 79 per cent. residue on the 10,000-mesh sieve. In order therefore to grind 150 kgs. of fresh material plus return, it will be necessary to employ grinding bodies of $1.5 \times 1.9 = 2.85$ kgs. as a maximum expenditure. In this illustration no consideration has been taken of the fact that the fine returned material requires a considerably smaller amount of grinding work than the much coarser fresh charge. The saving in grinding media compared with one-pass grinding amounts to $\frac{4.5}{2.85} \times 100 - 100 = 58$ per cent.

The placing of an air separator behind the multi-chamber mill is at present being carried out in two cement works, a new multi-chamber mill with air separation is now on order.

Fig. 2 shows a multi-chamber mill with air separators. The cement flour coming from the mill is conveyed to a bucket elevator which charges the ground material into the air separator. In this air separator the charge is separated by a patent circuit system into fine flour and grits. In the air separator a fineness of the finished product within the limits of 0 to 10 per cent. and more residue on the 4,900-mesh sieve can be obtained as desired.

By means of the circuit regulator the grits are divided into two streams, by far the larger portion travelling back to the bucket elevator in order to be air separated afresh. The tailings, which are practically free from fine flour, run behind the feeding apparatus into the mill. The charging device therefore only feeds fresh material into the mill, whilst the return increases in a striking manner the content of the very finest flour within the product of the multi-chamber mill.

"ALITE" THE HIGHLY ALUMINOUS ($68\% \text{AL}_2\text{O}_3$)
 SUPER-REFRACTORY
 FOR BURNING ZONES
 (REFRACTORY-STANDARD CONE 36-37).

E. J. & J. PEARSON LTD., STOURBRIDGE, ENG.



EQUIPMENTS

For removal of Dust, Steam or Fumes + Ventilation of Buildings,
Mines & Ships + Mechanical Boiler Draught + Cooling & Drying + Air
Conditioning + Pneumatic Conveying.

Sirocco Centrifugal, Dust & High Pressure Fans.


DUST COLLECTORS for
Chimney Gases and general
Industrial purposes.

**AIR WASHERS + AIR
HEATERS** (Steam or Direct Fired)
Steam Turbine Heater Units.

DAVIDSON & CO., LIMITED,

Sirocco Engineering Works, Belfast.

LONDON, MANCHESTER, BIRMINGHAM, NEWCASTLE, CARDIFF, BRISTOL, GLASGOW.



PAPER SACKS FOR ALL PURPOSES
THE MOST RELIABLE
FOR EXPORT TRADE.

**OUR
PAPER SACKS**

ARE MORE ECONOMICAL FOR THE
CEMENT MANUFACTURER
AND
HANDIER FOR THE USER

SEND FOR FULL PARTICULARS.

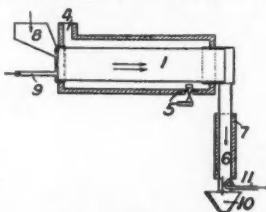
DOWDINGS LTD.
LITTLE EATON, DERBY,
ENGLAND.

Recent Patents Relating to Cement.

Cements. LÉPINE (née ROUSSEL), M. T. J., Villa Mary-Pierre, Chemin de Velours, Meaux, France. July 3rd, 1930. No. 358,006.

A raw cement charge is burned in a medium which is simultaneously aqueous, alkaline and reducing. Iron oxide such as Fe_2O_3 may be similarly treated to reduce it to Fe_3O_4 and may then be added to an

ing character by hydrogen, steam, ammonia or water gas. Metallic iron, platinum, or nickel may also be added to the charge. As shown, a kiln comprises a movable chamber 1 lined with nickel, a feed hopper 8, a burner 5, a chimney 4, a pipe 9 feeding the gases in, a tempering (i.e. cooling) chamber 6 cooled by a refrigerator 7, a receptacle 10 and an aspirator 11.

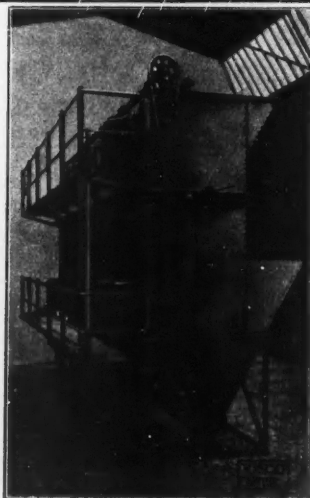


CEMENT KILN.

ordinary, flat or spent cement to improve its qualities. The cement charge after burning may be suddenly cooled in the same atmosphere, thus further improving its qualities. The alkalinity may be produced by adding sodium, potassium or ammonium salts or bases to the charge, and the reduc-

Burning Cement, Lime, Ores, etc. Metallges. Akt.-Ges., 45, Bockenheimer Anlage, Frankfurt-on-Main, Germany. Oct. 7th, 1930. No. 355,564.

A process for sintering cement, lime, dolomite, magnesite, and ores of carbonate or oxide character consists in calcining the material in a first furnace using just sufficient fuel to effect the expulsion of the carbon dioxide and water, and then sintering the calcined material, after the addition of just sufficient fuel to effect the sintering, in a blast apparatus through which air is drawn or forced, e.g., a Dwight-Lloyd apparatus. Fine grained clinker or blast furnace slag may be added to the charge to be sintered. The calcining may be effected in a rotary kiln, shaft furnace or blast apparatus, but the sintering must be effected in a blast apparatus.



"VISCO"

ENGINEERING CO. LTD.
162 GROSVENOR ROAD, LONDON SW1

Telephone: Victoria 6521/2.
Telegrams: "Overmill, Charlton, London."

VISCO - BETH DUST COLLECTORS

are supplied for

FINE GRINDING MILL

and

PACKING PLANT

at

GREEN ISLAND CEMENT
WORKS, HONG KONG.

Illustration shows One Dust Collector partially
erected before shipment.

Specialists in:

AIR FILTERS, INDUSTRIAL VACUUM CLEANERS,
HEATING & VENTILATING PLANT, COOLING
TOWERS, etc.

Notes from the Foreign Press.

Investigation of Cement by Vapour Pressure Measurements. F. Krauss and G. Jörns. *Zement*, Vol. 19, p. 1054, 1930, and Vol. 20, pp. 314, 341, 1931.

The hydration of technical Portland cement and of various synthetic melts was investigated by the method of evacuating a reaction chamber containing a weighed quantity of the substance and then heating until an agreed pressure (generally 7 mm. of mercury) is attained. The water content of the material is obtained by weighing after each operation and is plotted against temperature to give the isobaric curve. A portion of the curve at which temperature remains constant while water content changes indicates the existence of a hydrate.

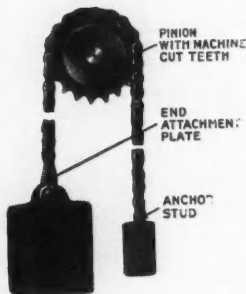
Synthetic mixes of pure materials were fused and quenched. The material was powdered, mixed with water, and allowed to set in moist air. It was then dried, powdered and its isobar determined.

A melt of composition $3\text{CaO}.\text{SiO}_2$ was first taken. The hydrated material, of composition $3.02\text{CaO}.1\text{SiO}_2.2.03\text{H}_2\text{O}$, was observed for three months. The steps in the curve were not so well defined as with pure compounds, probably due to the simultaneous dehydration of compounds and colloids or solid solu-

TAKE ADVANTAGE

of the economy offered by

RENOLD CHAIN SETS



Full Particulars are given
in Booklet Ref. No. 016/33
sent free on request.

for Counterweight and Rack operation. As standardised parts made on a quantity production basis, they hold a great price advantage over cases where small quantities have to be made to suit special requirements. The various attachments are of accurately made compact design, and are proportionate in strength to the Chain on which they are used.

The RENOLD and COVENTRY CHAIN COMPANY LTD.
MANCHESTER, ENGLAND.

Agencies and Depots in all parts of the World.

tions. Three steps were found, two at 30 and 100 deg. C., corresponding to dehydration of $\text{SiO}_2 \cdot 3\text{H}_2\text{O}$ to the dihydrate and thence to the monohydrate, and the third at 400 deg. to dehydration of $\text{CaO} \cdot \text{H}_2\text{O}$. The last accounted for 1 mol. H_2O , so that it may be assumed there was 1 mol. of free CaO resulting from decomposition either in the melt or during hydration.

The melt $3\text{CaO} \cdot \text{Al}_2\text{O}_3$ after setting had the composition $3.03\text{CaO} \cdot 1\text{Al}_2\text{O}_3 \cdot 4.50\text{H}_2\text{O}$. Complete dehydration was not attained even at 650 deg. The most important constant temperature step was at 200 deg. (aluminium hydroxide), and accounted for more than 1.5 mols. H_2O . The $\text{CaO} \cdot \text{H}_2\text{O}$ step was only suggested. There was a clear step at 120 deg., the cause of which was uncertain. The steps were much better defined than in the former melt.

A melt $8\text{CaO} \cdot 2\text{SiO}_2 \cdot \text{Al}_2\text{O}_3$ (Väneckeite) was investigated. On hydration it contained $12\text{H}_2\text{O}$. The pronounced step at 200 deg. was now only suggested, while the $\text{CaO} \cdot \text{H}_2\text{O}$ step had disappeared. There was a small step at 300 and a definite step at 100 deg.

Various technical Portland cements were then investigated. (1) Two cements were treated after hardening for two days. The curves were mainly zeolitic, but two hydrate steps were clearly shown, one at about 50 deg. and the other at 375 deg. ($\text{CaO} \cdot \text{H}_2\text{O}$). (2) Two cements allowed to harden for 28 days under water and in moist air showed a number of steps, some below 100, others at 200 and 375, and one above 500 deg.

The work is being continued, and full discussion will be reserved until its completion.

INDEX TO ADVERTISERS.

Allen, Edgar, & Co., Ltd.	ix	Hudson, Robert, Ltd.	viii
Avery, W. & T., Ltd.	xiii	Humboldt Deutzmotoren	x
Babcock & Wilcox, Ltd.	xviii	Klöckner-Werke, A.-G.	xxiii
British Thomson-Houston Co., Ltd.	—	Krupp Grusonwerk	xxii
Brown, John, Thos. Firth & Co., Ltd.	xv	McEwan, J., & Co., Ltd.	vii
Chemisches Laboratorium für Tonindustrie	xiv	Metropolitan-Vickers Electrical Co., Ltd.	—
Constantin, E., Ltd.	iv	"Miag" Mühlenbau und Industrie, A.-G.	xi
Crompton Parkinson, Ltd.	—	New Conveyor Co., Ltd.	xiv
Davidson & Co., Ltd.	xxiv	Newell, Ernest, & Co., Ltd.	Front Cover
Davison, Charles, & Co., Ltd.	—	Pearson, E. J. & J., Ltd.	117
Diamond Lubricating Co., Ltd.	xvi	Polysius, G.	vii
Dowdings, Ltd.	xxiv	Renold & Coventry Chain Co., Ltd.	119
Evrard, F., & R. Frère	—	Richter, Oscar A.	—
Ewart Chain Belt Co., Ltd.	v	Rolland, John, & Co.	xxii
Fellner & Ziegler	xii	Ross Patents, Ltd.	xvii
Firth, Thos., & J. Brown, Ltd.	xv	Ruston-Bucyrus, Ltd.	xix
Fraser & Chalmers Engineering Works	x	Ruston & Hornsby, Ltd.	—
Frère, R., & F. Evrard	—	Sack Machinery Co., Ltd.	xi
Fuller Company	iv	Smidth, F. L., & Co., Ltd.	ii, iii
General Electric Co., Ltd.	x	Taylor, J. Darnley, & Co., Ltd.	xii
Glover, W. T., & Co., Ltd.	vi	Tonindustrie, G.m.b.H.	xiv
Grueber, Curt von	—	Vickers-Armstrongs, Ltd.	xx, xxi, xxv
Helipets, Ltd.	viii	Visco Engineering Co., Ltd.	118
Holman Bros., Ltd.	xv		